

Fig. 1

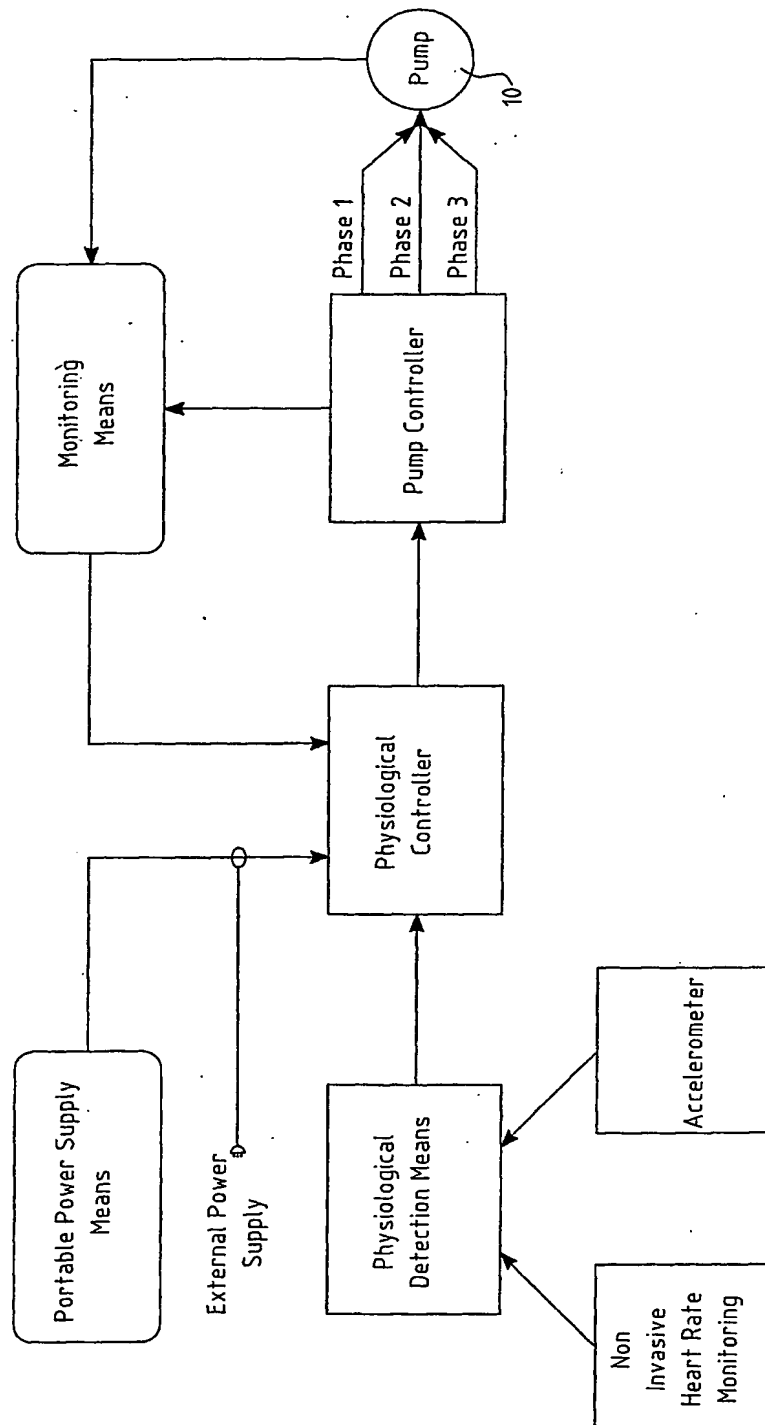


Fig. 2

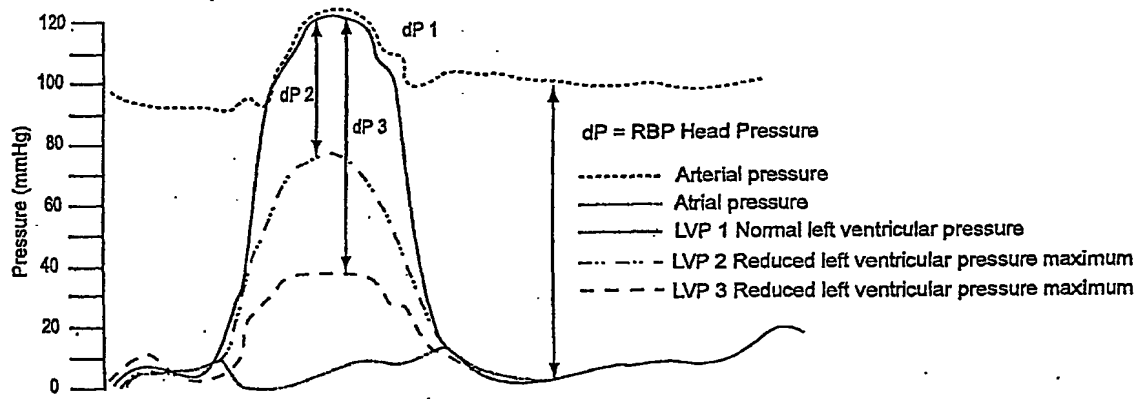


Fig. 3

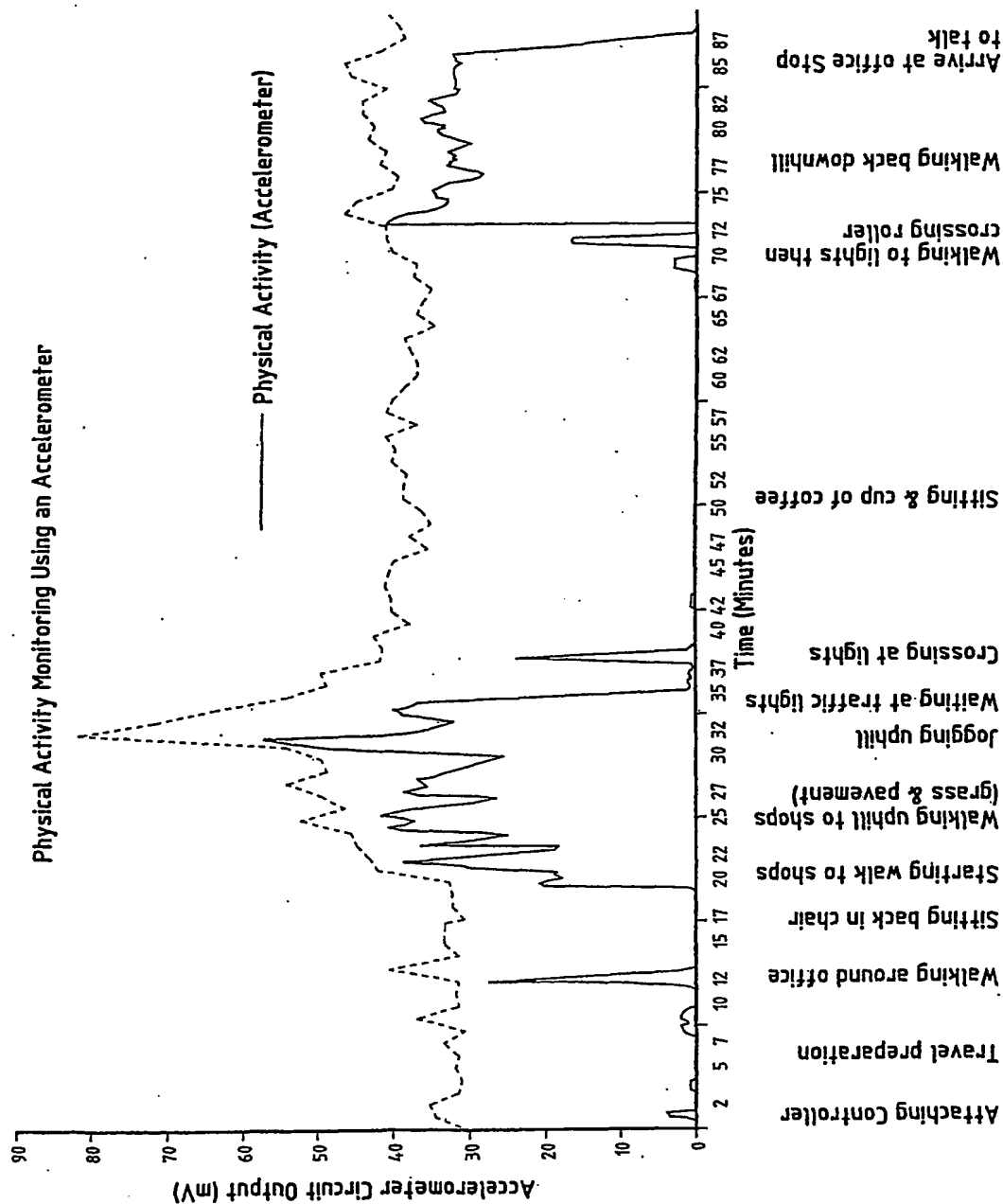


Fig. 4

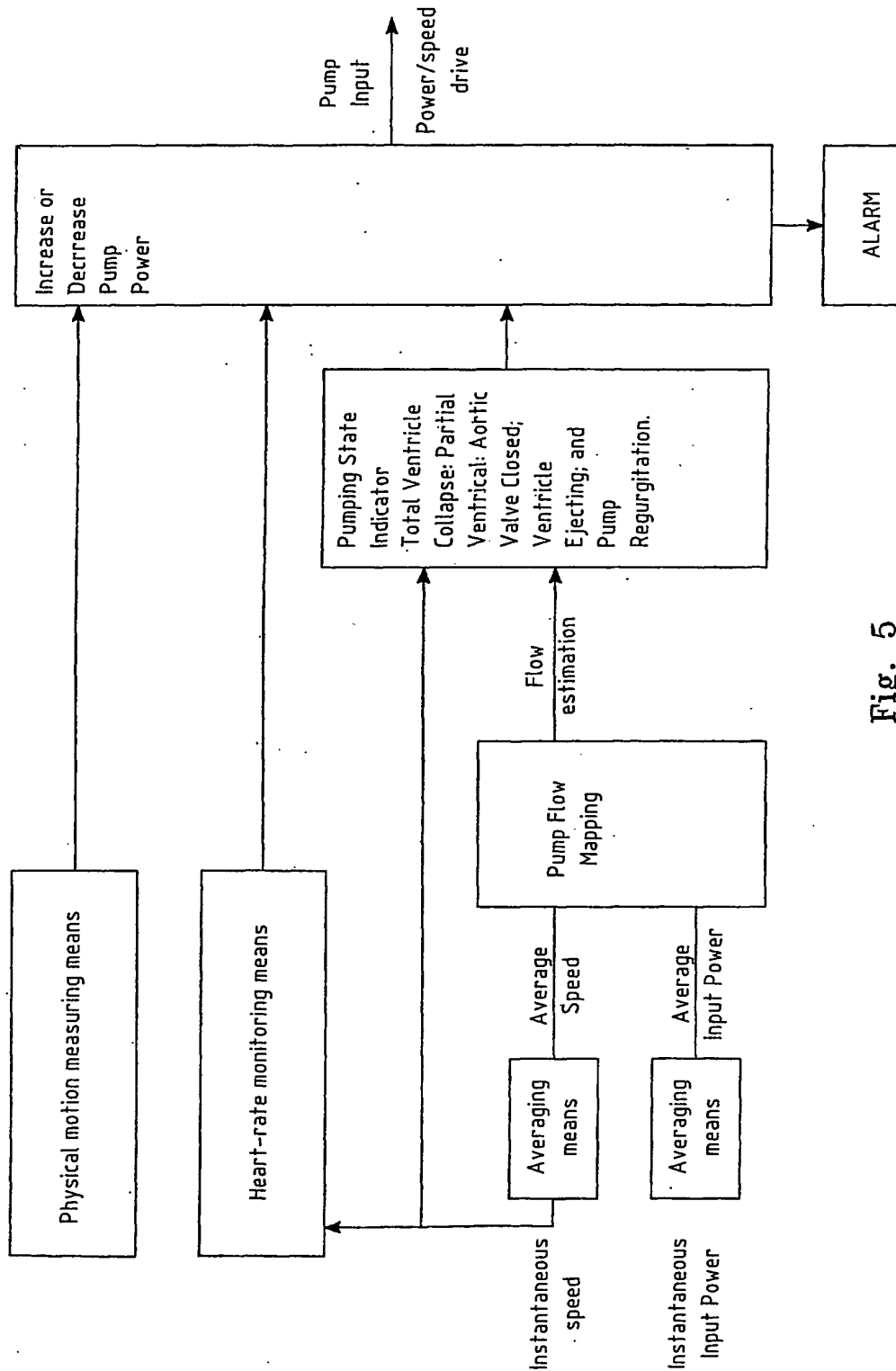
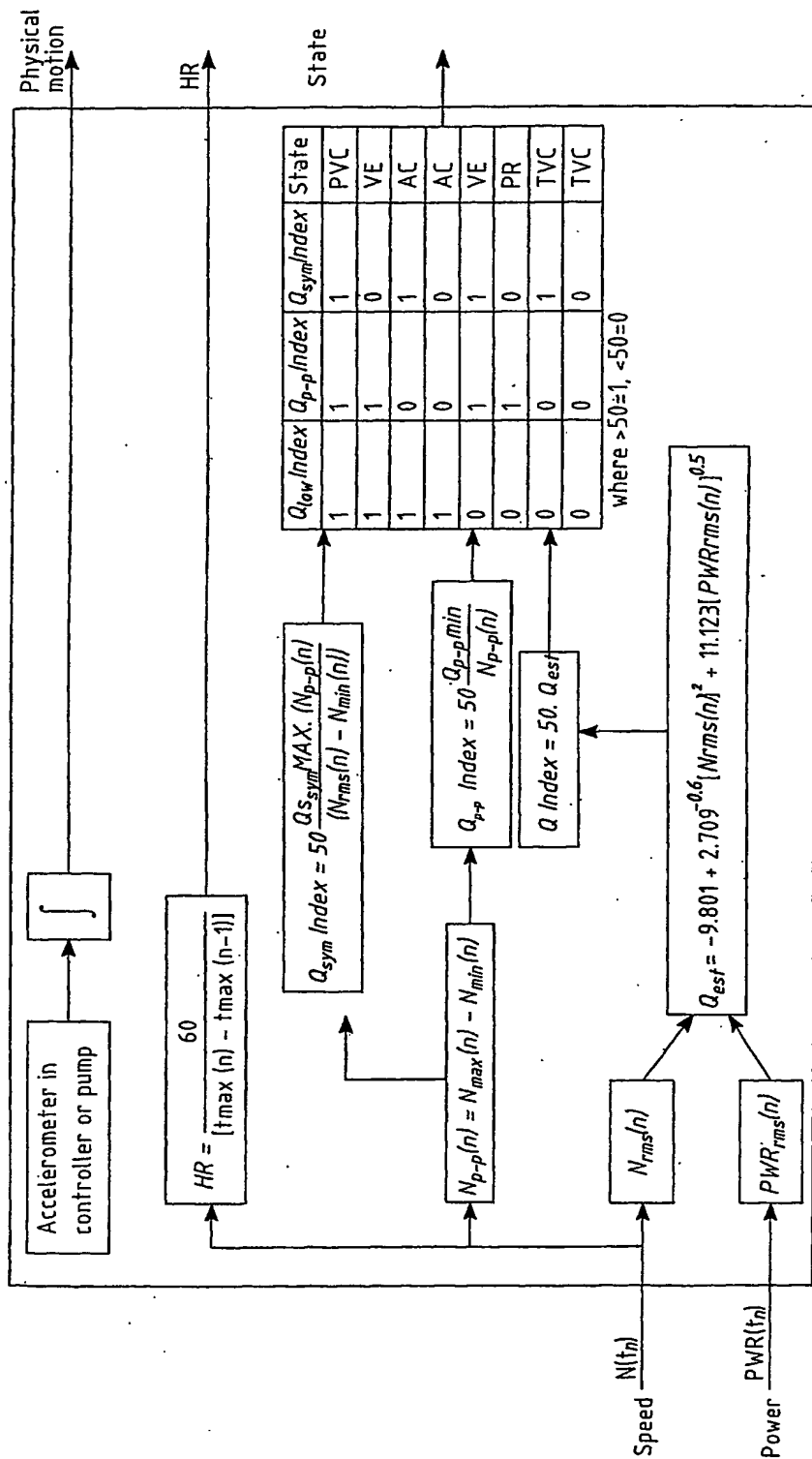
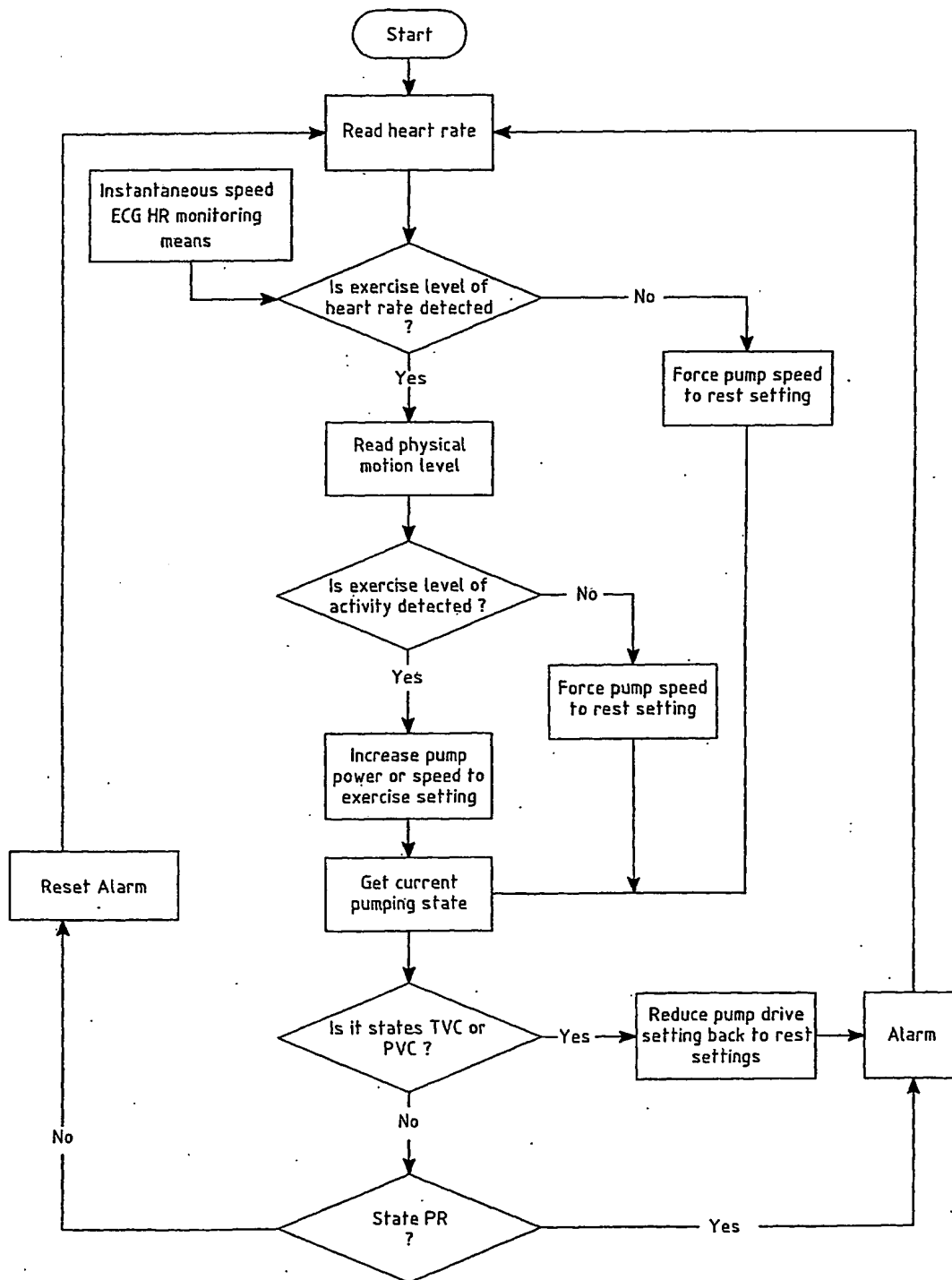


Fig. 5



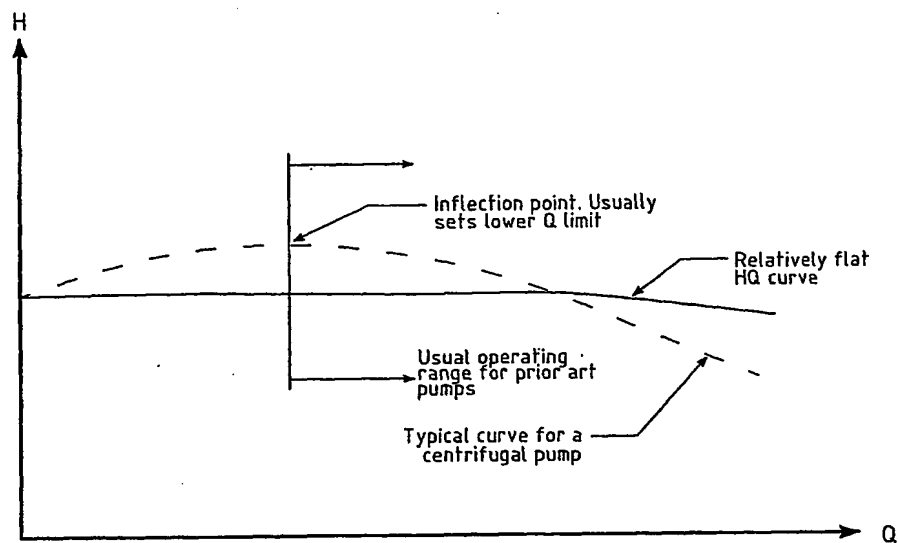
A block diagram of the Pumping state detection module. From Instantaneous pump speed and power ($N(t)$, $PWR(t)$), rms speed and RMS power ($N_{rms}(n)$, $PWR_{rms}(n)$) were derived. From the RMS parameters, pump flow, $Q_{est}(t)$ was derived. Pumping state indexes for PVC, AC, VE, PR were generated from the RMS and instantaneous speed parameters given flow rate boundaries. Heart rate derived from $N(t)$ and physical motion integrating the output of an accelerometer mounted in the controller or pump.

Fig. 6



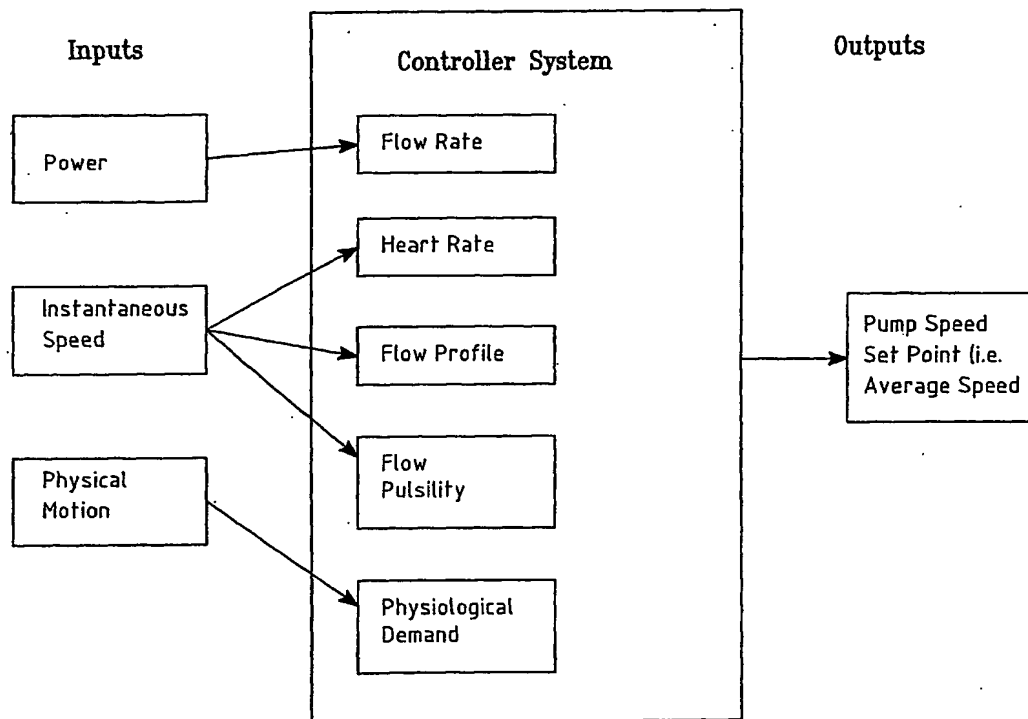
Flow chart for determining pump drive set point change through the integration of the 3 methods of non-invasive detection (physical motion, HR and state detection) for exercise rate response control.

Fig. 7



HQ curves for the pump and a typical centrifugal pump which exhibits a peak in the HQ curve.

Fig. 8

Physiological Demand Responsive Control System**Fig. 9**